Quantitative estimation of soil erosion in the Larga catchment - Tigheci Hills

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ABSTRACT: Soil erosion is a severe form of soil degradation. Factors influencing this process, produced by water and wind on the soil surface, do not act in isolation, but in a complex and interdependent manner. For quantitative estimation of soil erosion, it was applied the universal soil loss equation, adapted by Moțoc et al. (1975) for soil and climate conditions of Romania. The input data were the digital terrain model, soils and land use maps. Rainfall erosivity was considered constant. Soil erodibility was determined based on soil type, texture and degree of surface erosion. Vegetation influence was quantified based the normalized difference vegetation index derived from Landsat images. These erosion control factors were derived in raster format, from their integration resulting the estimated potential and actual surface erosion.

KEY WORDS: soil erosion, USLE equation, Larga catchment, Tigheci hills

1. Introduction

The Larga catchment is located in the south-west of the Republic of Moldova, being part in the physical-geographical unit of Tigheci Hills (fig. 1). The total length of the river is 32.3 km and the total area of the basin is 146.8 km^2. According to this dimension the catchment is included in the category of medium-sized watershed.

In geological terms, the surface deposits belong to the upper Sarmatian (Chersonian and Meotian) Pliocene, Pleistocene and Quaternary formations. The lithological deposits are represented mostly by sands and clays, leading, in particular, to the occurrence and manifestation of the erosion and mass movement processes.

In morphometric terms, the Larga catchment is characterized by altitudes between 50 m and 300 m, the average elevation being 145 m. The average slope angle exceeds slightly 4.5o, decisively influencing erosion. The main landforms are relatively diverse, relief typology makes itself visible through a clear dominance of the sculptural (fluvio-denudational) relief developed on a generally monocline structure (88.5 % of the total). The soil cover is characterized by homogeneity at the type level, with an obvious dominance of Chernozems (about 75% of the total of agricultural soils).

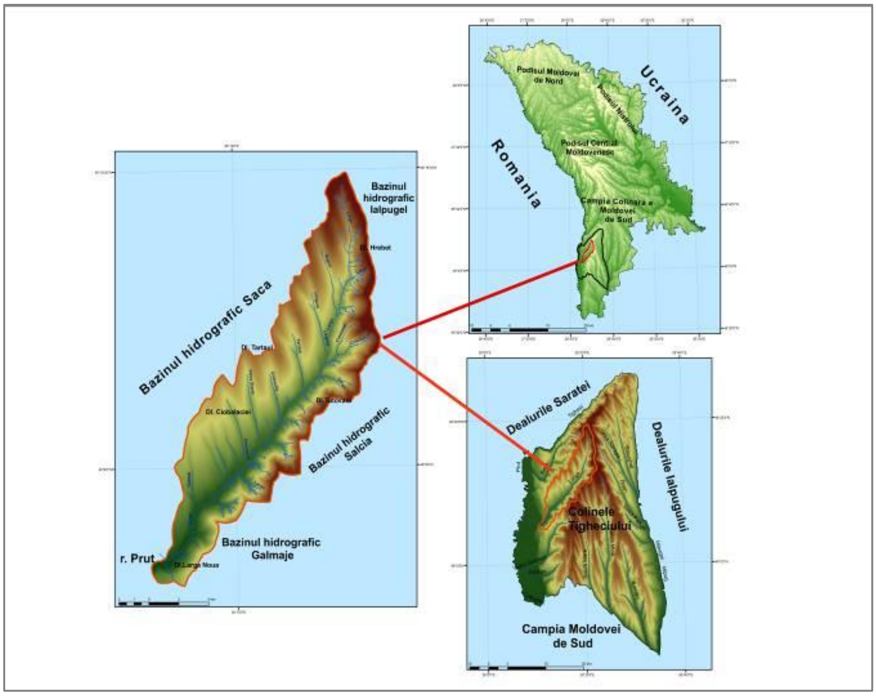

Figure 1 Position of the studied catchment within the Republic of Moldova.

This situation explains in a good measure the dominant agricultural character of the economy of the study area, which is accompanied by other important natural resources, but is endowed with a soil cover capable of sustaining high-performance agriculture.

2. Materials and methods

The quantitative assessment of soil erosion requires a scientific approach as accurate as possible. Thus, since the 70s a series of soil loss equations have been published, based on the different factors that determine soil erosion: Wischmeier W., Smith D., (1978), Stănescu P. (1975), Slastihin V., (1964), Mirțhuleava Ț., (1978), Moțoc M. (1975-1979).

In the Larga catchment, soil erosion was estimated by processing the data from soil studies for localities Larguta, Haragis, Cirpesti, Lingura, Tartaul, Plopi, Ciobalaccia, Cucoara, Chircani, Rumeantev and Gotesti conducted by the Institute for Soil Science, Agrochemistry and Soil Protection „N. Dimo" I.P.A.P.S., Chisinau. Classification criteria were correlated with those of the I.C.P.A.-1986 (MESP, 1987).

In a geographical setting similar to the one of right tributaries of the Prut river, the equation developed by Motoc et. al. (1975, 1979) was applied for the study region in order to estimate the average annual soil loss (fig. 2):

$$\mathbf{E = K \times L^{0,3} \times (1,36 + 0,97 \times I + 0,138 \times I^2) \times S \times C \times Cs}$$

where:

E - multiannual average erosion rate (t/ha/year);

K - rainfall erosivity coefficient;

L - slope length (m);

I - slope angle (%);
S - correction factor for soil erodibility;
C - correction factor of the effect of vegetation;
Cs - coefficient for soil conservation practices.

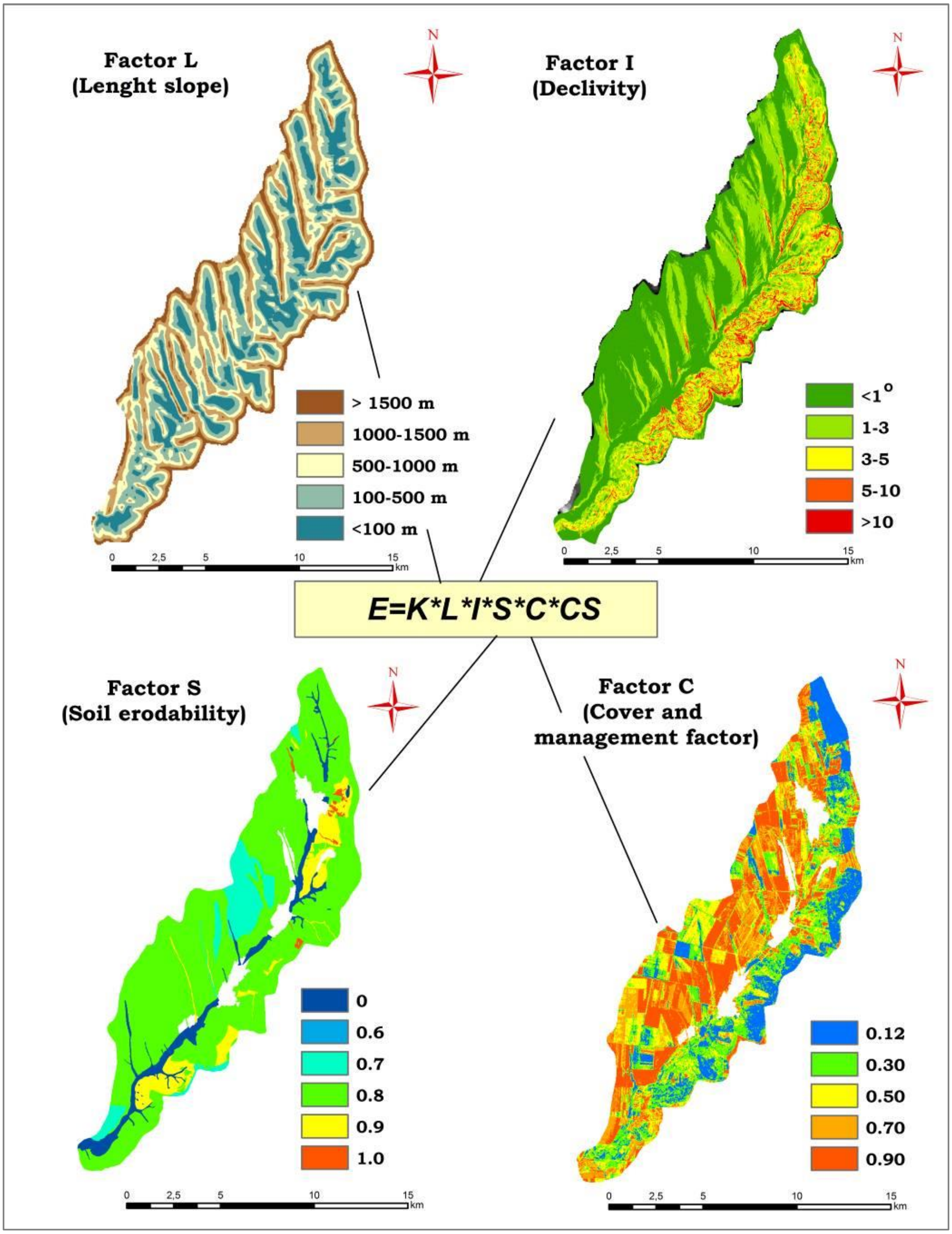

Figure 2 Quantification of surface erosion factors using the Motoc et al. (1975) relation in Larga catchment.

- The **K factor** value was extracted from the rainfall erosivity zoning map of Romania (ICPA, 1987) and it applied to the studied area.
- The **L factor** was determined based on the digital elevation model using the Topographic Indices module from SAGA GIS application.
- The **slope angle** (**I)**, as well as the **slope length (L)**, were derived from DEM using Spatial Analyst Tools from ArcGIS 9.3.
- The **S factor** was obtained based on soil type/subtype, soil texture and the degree of surface erosion, according to the ICPA methodology (1987), starting from soil maps at scale 1:10000.
- The **C factor** was computed from a set of Landsat images from the year 2003, based on the normalized difference vegetation index (NDVI) (Jong et al., 1998).
- The **Cs factor** measures the effect of soil conservation practices, but since within the study area such practices are weakly represented, this factor is not taken into account.

3. Results and discussion

The pedological studies (figs 3 and 4) show that in the study area about 4500 ha (37.11% of total surface) are affected by moderate erosion, on 3421.32 ha (28.35%) prevail low erosion and 2595.15 ha (21.50%) are highly eroded.

The lands with very high and severe erosion are more widespread on cuesta fronts, representing about 6 % of the study area (694.91 ha), while terrains not affected by erosion hold a total of 876.65 ha (7.26%).

Figure 3 Moderate eroded soil on the backslope with south-east aspect, south of Flocosica village.

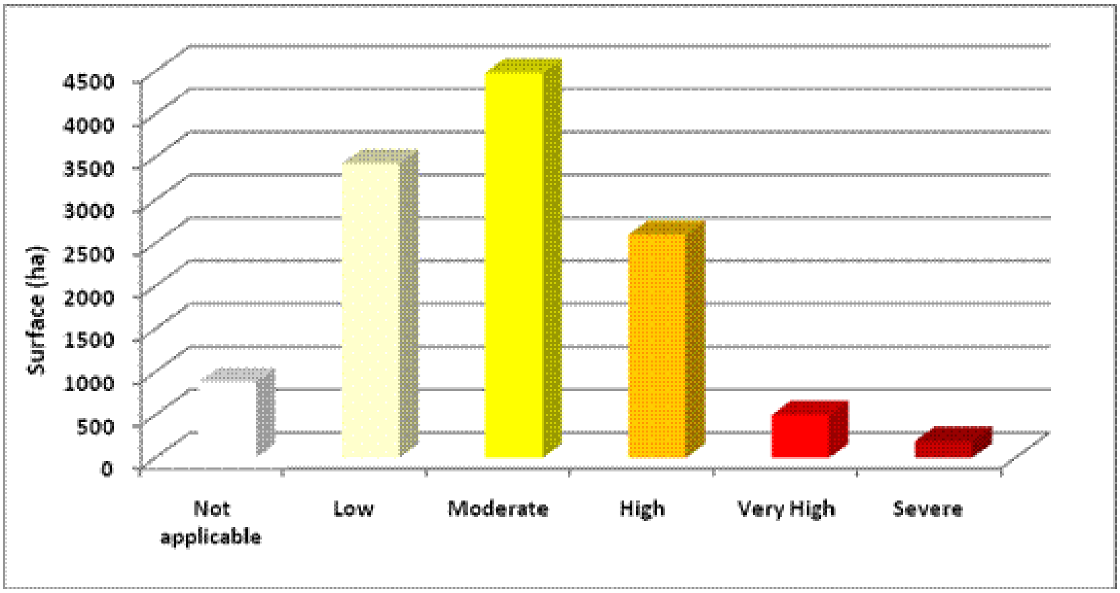

Figure 4 The area of soil erosion on intensity classes (after processing pedological studies at scale 1:10 000, by IPASP).

According to the soil erosion map (fig. 5) it is noted that the low eroded lands occupy gentle slopes which generally correspond to backslopes. The highest erosion is observed in the middle third of the slopes and the detached materials are redistributed in the lower third of slopes. Morphologically, this process is reflected in the formation of a slight convexity or, more clearly, within the existing crops which are much better developed compared to the middle third of the slopes, due to the additional contribution of humus transported along slopes. On terrains used for the grazing, covered with herbaceous vegetation, the intensity of erosion is reduced, but on the cuesta fronts, where overgrazing occurs, the lack of vegetation leads to excessive erosion rates.

Leaving out the influence of vegetation and soil conservation practices, the potential erosion was quantified by means of only pedological and geomorphological factors. Based on calculations, in the studied area, the average value of potential erosion is 10.4 t/ha/year, a value that fits in a moderate degree of erosion.

From fig. 6 the lands with low potential erosion (< 8 t/ha/year) account for 43% of the total area and occupy the sculptural plateaus, hilltops, backslopes and floodplains. Areas with potential erosion values between 8-15 t/ha/year correspond to moderate erosion risk and overlap the back cuesta, characterized by slopes of 5-10°.

The high potential erosion (15-30 t/ha/year) characterizes the cuesta fronts, which are especially present on the left side of the basin. The lands with very high and severe soil erosion (over 30 t/ha/year) represent about 13.5% of the study area and they overlap the steep banks of gullies and scarps (fig. 7).

The integration of the vegetation influence has led, further, to the quantification of the effective erosion within Larga catchment. The lack of information concerning soil conservation practices did not allow us to integrate this factor in the soil loss equation. However, this shortcoming does not particularly affect the results due to the low weight of such soil conservation practices.

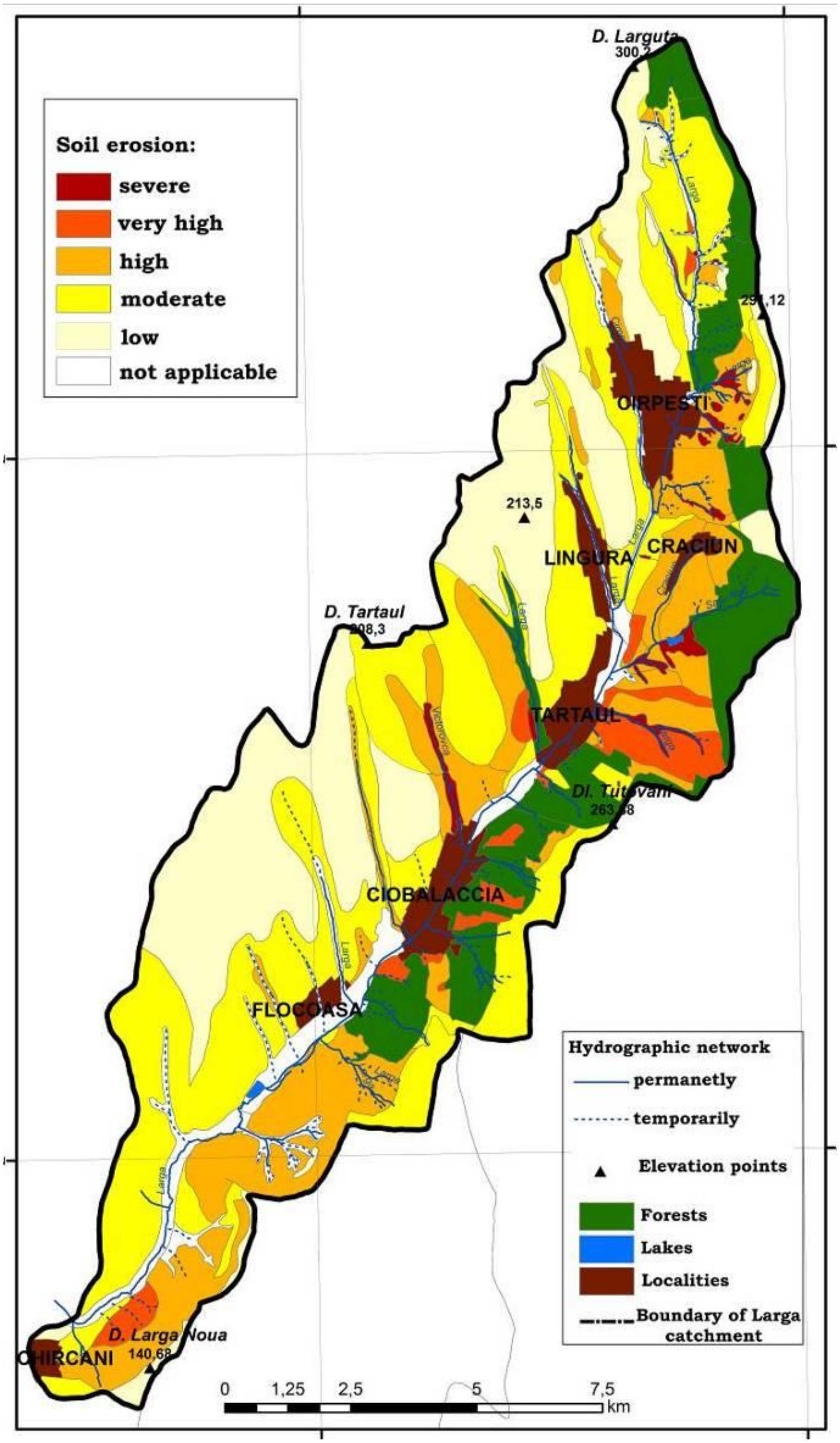

Figure 5 Soil erosion map in Larga catchment (after processing pedological studies in scale 1:10000, made by IPAPS).

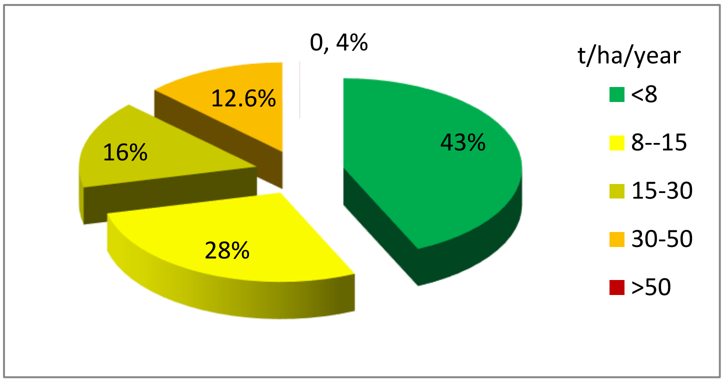

Figure 6 Percentages of potential erosion classes in the Larga catchment.

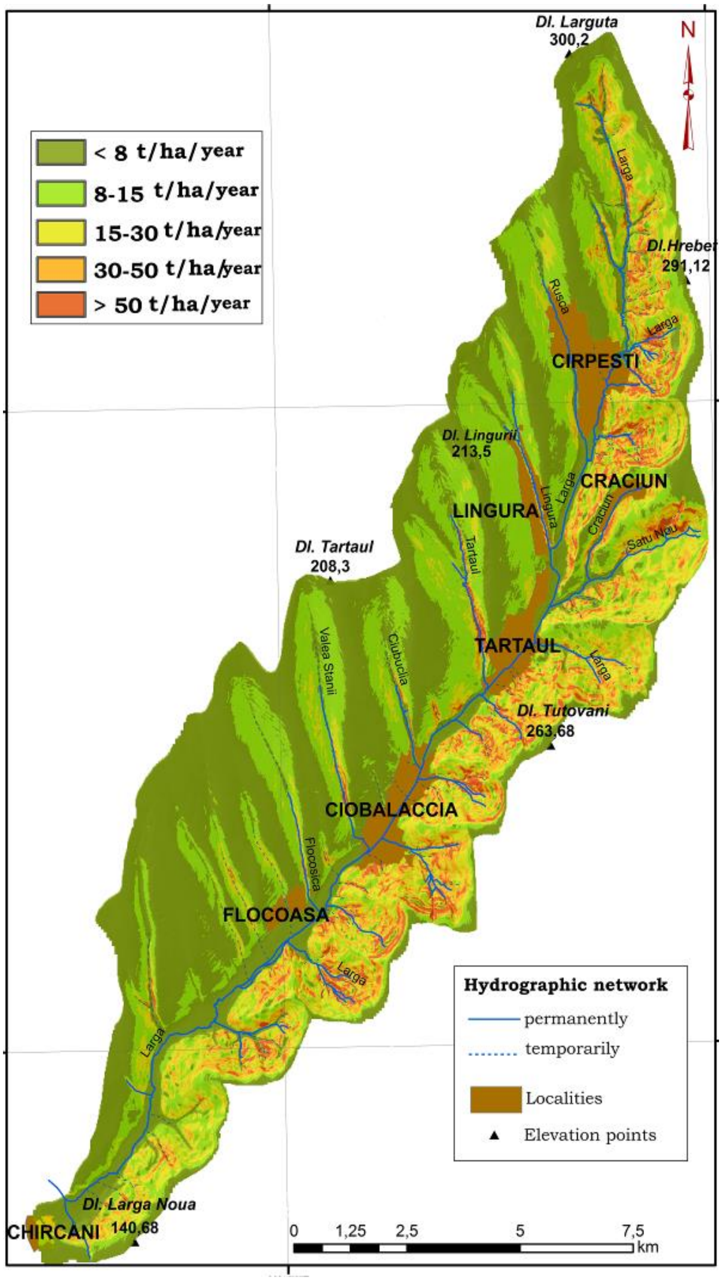

Figure 7 Potential erosion map in the Larga catchment.

After analyzing this information, it was concluded that for studied region, the mean annual rate of soil erosion is 6.7 t/ha/year, much lower than potential erosion due to the effect of vegetation that hinders surface erosion. However, the highest frequency (42.73%) of soil erosion with rates less than 5 t/ha/year (fig. 8) are associated with sculptural plateaus and hilltops, floodplains and gentle backslopes (fig. 9).

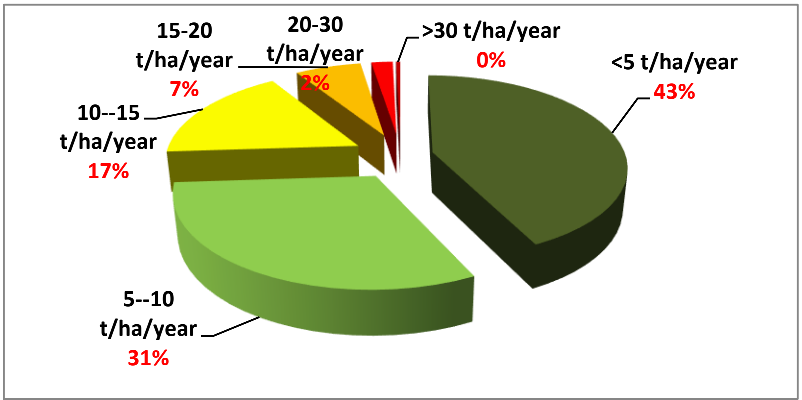

Figure 8 Percentages of effective erosion classes.

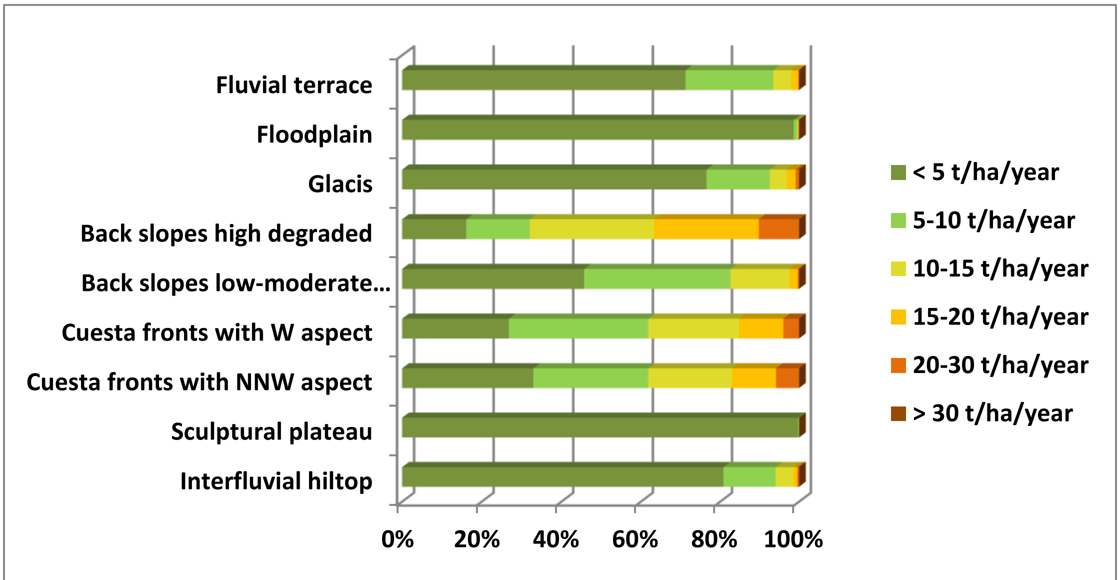

Figure 9 Percentages of mean annual soil loss classes according to landforms.

A significant weight of over 30% have the lands with 5-10 t/ha/year soil loss, which occupy the lower third of cuesta fronts areas with north-west and west aspects. The areas with soil loss of 10-15 t/ha/year and 15-20 /t/ha/year correspond to cuesta fronts and hold a weight of 16.9% and 6.51% respectively. Instead, the areas with very high (20-30 t/ha/year) and severe erosion (>30 t/ha/year) are mainly distributed on the landforms that have a stronger declivity, such as the highly degraded backslopes, the steep banks of gullies and scarps (fig. 10).

Taking into account lithological and morphoclimatic conditions similar to Larga catchmet were achieved results about average rate of surface erosion in southern Central Moldavian Plateau, which is 4-5 t/ha/year (Patriche, 2005).

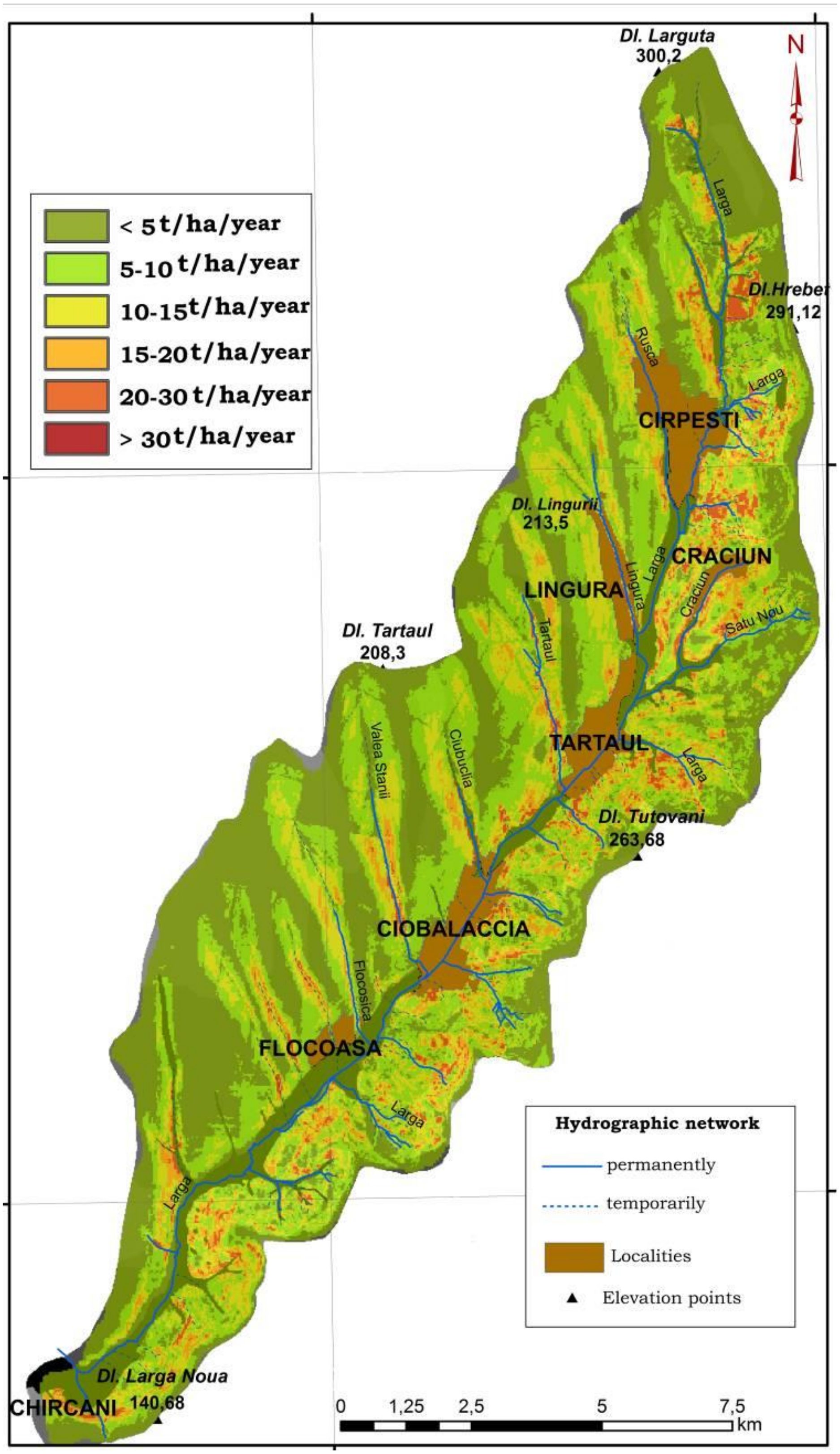

Figure 10 Effective erosion map in the Larga catchment.

4. Conclusions

The application of USLE equation adopted Motoc et al. (1975, 1979) proves extremely useful for estimating the average soil loss through surface erosion. Applied in Geographic Information Systems, this equation is especially suited for regional studies.

The Larga catchment has an area of 146.8 km^2 and among the present geomorphological processes, the surface erosion has the highest spatial extension and manifests with different intensities on about 70% of the whole territory. On cuesta backslopes, the intensity of erosion is low, but on the fronts, with slopes over 15^o, there are present areas without vegetation which may lead to excessive high erosion rates. According to the IPAPS classification, the study area falls within the class with a moderate degree of erosion, and based on the USLE the average annual soil loss often reach 7 t/ha/year, representing the annual allowable limit value for arable lands.

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